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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: C.4.2

United States of America

PROTECTION FROM INSECT AND VERTEBRATE PESTS IN RELATION TO CROP PRODUCTION

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PROTECTION FROM INSECT AND VERTEBRATE PESTS IN RELATION TO CROP PRODUCTION

by

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1. Insects and their allies, the ticks and mites, constitute a continuing threat to agricultural production. They are man's chief competitor for food and fiber. Every crop plant is subject to attack by a variety of insect pests. Damage may begin when the crop is planted, continue throughout its growing period, and persist even after harvest when products are placed in storage. In addition to such direct damage, insects are responsible for the spread of some of the most serious diseases affecting plants. Although arthropods take a heavy toll of agricultural production, many of these small creatures are beneficial to agriculture. Insect parasites and predators help to reduce the abundance of destructive insects, and the honey bees and other insects are essential for the pollination of many plants. In addition to the invertebrates, the vertebrate pests, including rodents and birds, compete with man for available food supplies and may also serve as reservoirs for important diseases. Thus, pest control for the welfare of man represents a major problem throughout the world.

Regulatory Programs Relating to Insect Control

2. The first line of defense in insect control involves quarantine activities. Most of the major crop pests in the United States have been accidentally introduced. Due to the increase in international travel and the high speed of modern transportation, adequate quarantines to detect and prevent the introduction of plant and animal pests are difficult to establish and maintain. However, this quarantine activity is regarded as one of the most essential and fruitful of the various insect-control efforts.

3. The United States maintains an insect-survey program designed to detect new introduced pests as quickly as possible and to obtain information on the seasonal abundance of established insects. Programs are maintained to prevent the spread of foreign pests and to deal with outbreaks of certain native pests.

4. Although public agencies contribute materially to the solution of insect problems by instituting various quarantine and control activities, most insect problems are met by the growers themselves, who follow the control procedures developed through research by public and industrial organizations.

Research and Progress on Various Methods of Insect Control

5. Many procedures for the control of the more important insect pests of crops and livestock have been investigated in the United States during the past 100 years that such research has been actively supported by Federal and State agencies. Major attention has been centered on the following procedures: Cultural and sanitary

measures; importation of parasites and predators of destructive insects as well as importation of insects for control of certain noxious weeds; development and use of insect pathogens; development of crop varieties that resist insect attack; use of attractants, including chemical or food baits, and light traps; and investigation of insecticides and other chemicals for the destruction of insects. In addition to the insect-control procedures mentioned, a new approach to insect control, involving the use of insects for their own destruction by releasing sexually sterile males, has during recent years received considerable attention in research.

Cultural Measures

6. Proper sanitary, cultural, or management practices are basic requirements in meeting some of the insect problems. However, the degree of control that can be achieved by such practices is often inadequate to meet the high standards of efficiency desired. Nevertheless, the level of insect populations can often be greatly reduced by following good cultural, management, or sanitary practices.

7. For example, the pink bollworm--a major threat to cotton production in the United States and one of the most destructive pests in a number of cotton-growing areas in the world--is relegated to the role of a minor pest of cotton in the United States because of the adoption of certain cultural measures (U.S.D.A. 1953). In south Texas, where the insect is most prevalent, regulations in force for a number of years establish each year the last date on which cotton may be planted and also a date before which all cotton must be harvested and the cotton stalks destroyed so as to prevent late season pink bollworm development and high overwintering populations. Thus, cultural measures, plus some control resulting from the use of insecticides for other cotton insects, generally prevent high losses due to the pink bollworm. The cultural measures prescribed for the pink bollworm also contribute materially to the control of the boll weevil in the pink bollworm areas. The application of such control measures requires knowledge of the life history and habits of the pest involved and, almost always, a community-wide cooperation by growers. Cultural measures alone, however, are often inadequate to solve the problem completely and supplementary measures should be developed in the event they are required.

Use of Parasites and Predators

8. The value of natural control factors, particularly parasites, predators, and insect pathogens, for regulating destructive insect populations is generally recognized. Experience in the United States indicates that for native insect pests the total influence of natural enemies is sometimes great enough to keep many of these pests under reasonable control. However, local or regional outbreaks of such native pests may occur from time to time; thus, to prevent excessive crop losses, control measures must be developed and applied when needed. Insects that have been accidentally introduced into the United States do not harm the usual number of natural enemies. In spite of efforts to introduce such enemies from the native home of the pest, natural control factors are generally less effective for these insects than for native pests.

9. Considerable attention is being given to the integration of chemicals and biological control. This technique involves the selection of suitable insecticides and dosage rates and the timing of applications so that minimum damage to the parasite and predator complex will occur. Several workers have demonstrated the value of limiting the use of insecticides as a supplement to natural control forces.

10. Excellent results have been obtained with introduced parasites and predators for controlling several destructive pests. These include the cottony-cushion scale (Icerya purchasi (Maskell)), Comstock mealy-bug (Pseudococcus comstocki (Kuwana)), and Japanese beetle (Popillia japonica(Newman)) in the U. S. and the citrus blackfly (Aleurocanthus woglumi (Ashby)), in the West Indies and Mexico. In many other

instances the introduction of parasites and predators has shown no significant control of the host insects. Although complete success is not often achieved, the investment in funds allocated to the search for and introduction of natural enemies is regarded as one of the most worthwhile that can be made to help meet insect problems.

11. The investigation of natural enemies of insect pests in various countries and the exchange of such insects represent ways in which countries can cooperate effectively in overall efforts to help meet insect problems. The U. S. Department of Agriculture has provided parasites or predators for many nations for release and possible establishment to help control destructive species, and it is prepared to lend any possible assistance to the development of mutual exchange of beneficial insects. A program of growing significance, which offers excellent opportunities for mutual cooperation in research, is maintained through the use of funds provided under the Agricultural Trade Development and Assistance Act of 1954, more commonly known as Public Law 480. In countries where such funds are available, it is thus possible to obtain support for research on biological agents that may be of mutual interest to agriculture in the United States and the cooperating country.

Insect Pathogens

12. Research on the use of insect pathogens to control destructive insects is gaining more and more interest and support. Insects are subject to attack by a wide variety of pathogenic organisms, including viruses, bacteria, protozoa, fungi, and mematodes. Under natural conditions they help regulate insect populations, as do parasites and predators. Like the parasites and predators, however, they generally do not provide sufficient control. Epidemics of pathogenic organisms among destructive insects are often delayed until the host has virtually destroyed the crop. However, application of mass-cultured pathogenic organisms offers the same opportunities for controlling destructive insects as those presented by insecticides. The potential advantage of disease organisms over insecticides is that insect pathogens are nearly always highly specific in their action against insects and thus are less likely than most insecticides to be hazardous to vertebrates. Examples of successful use of insect pathogens include a bacillus (B. popilliae Dutky) isolated from the Japanese beetle, a cytoplasmic virus on the pine processionary moth (Thaumetopoca pityocampa) and a polyhedral virus and Bacillus thuringiensis var. thuringiensis on the alfalfa caterpillar (Colias eurethema Boisduval). B. thuringiensis var thuringiensis has been registered for use in the United States and is recommended for controlling a variety of insects affecting crops.

13. The exchange of information and cultures of insect pathogens as an aid in the development of promising insect disease organisms for controlling destructive insects represents another way that mutual benefits can be obtained through cooperation among different countries.

The Development of Crop Varieties Resistant to Insect Attack

14. In the United States entomologists and plant breeders have considerable research underway to develop crop varieties that resist insect attack. This desirable approach to insect control has, however, received far too little attention. Research on specific insects attacking certain grain and forage crops in the United States has met with substantial success. The control of the Hessian fly (Phytophaga destructor (Say)), on wheat is one of the most outstanding examples of this success. Other examples are varieties of alfalfa that are highly resistant to the spotted alfalfa aphid (Therioaphis maculata (Burton)), sweet corn varieties that are resistant to attack by the corn earworm (Heliothis zea (Boddie)), field corn varieties that are resistent to attack by the European corn borer (Ostrinia nubilalis (Hubner)), and sugarcane varieties that resist attack by the sugarcane borer (Diatraca saccharalis (F.)).

15. One of the chief disadvantages of the varietal-resistance approach to insect control is the long period of research and development usually necessary to find insect-resistant germ plasm in a crop and to incorporate this character into suitable varieties adapted to different regions or countries. However, once the resistance character has been incorporated, no additional cost for protecting the crop is necessary and no side effects to other organisms will result. From a long-range and world-wide viewpoint, this approach to insect control needs to be given appropriate attention. Research in this area also lends itself to effective mutual cooperation between countries. Insect-resistant germ plasm can be exchanged and used in breeding-improvement programs.

Use of Insecticides

16. The extensive use of insecticides is a major factor in the high degree of productivity of crops in the United States. As shown in Table 1, a wide variety of insecticides is available for controlling the many kinds of insects affecting agricultural crops.

17. Insecticides are necessary for a highly efficient agricultural economy, but their extensive use has led to several potential-hazard problems that are being investigated intensively by industrially and publicly supported institutions in efforts to resolve them. Many of the insecticides are of special value in protecting crops and livestock from insect attack because of their persistant residual action. However, this feature which is desirable from the standpoint of insect control, intensifies the problem of avoiding excessive residues on crops grown for human consumption. The problem is further complicated by the possible occurrence on animal feeds of insecticide residues, which may in turn be stored in meat and milk when the feed is consumed by livestock. The Federal Government and the different States have enacted laws and regulations that establish tolerances for pesticide residues in raw agricultural commodities. The U.S. Department of Agriculture and comparable state agencies are responsible for enforcing such laws and regulations. Insecticides, to be marketed, must have been shown to meet certain standards of efficiency and safety before they can be registered and sold. Increased attention is also being devoted in research by Industry and public institutions to the development of kinds of insecticides that do not leave residues in raw agricultural commodities.

18. Another problem that is of concern is the adverse effects of insecticides on beneficial insects, particularly parasites and predators. The adverse effects on the honey bee and other pollinating insects of certain insecticides are of concern to bee keepers and farmers who depend on honey bees for the pollination of crops. Conservationists are apprehensive about the immediate and long-range effects of pesticides on fish and wildlife. Many instances of loss of wildlife in localized areas due to insecticides are experienced each year. However, there is no indication that the overall abundance of fish and game has been reduced. Wildlife biologists and entomologists are developing closer cooperation in their research in efforts to develop insecticides and ways of using them to minimize such hazards.

19. The problem of insects becoming resistant to insecticides is also a matter of increasing concern. Basic investigations are underway by a number of State and Federal research institutions to help resolve this problem. Thus far it has been possible to develop satisfactory substitute insecticides for the insects that have become resistant to different insecticides.

Other Methods of Insect Control

20. In addition to the more conventional ways of meeting insect problems, new approaches to insect control that may be of great significance in the future are under investigation. The discovery of materials that are highly attrative to males

of certain tropical fruit flies represents an important advance in the detection and control of these insects of major importance as pests of fruits and vegetables in many parts of the world. Lures have been useful in trapping the oriental fruit fly (Dacus dorsalis Hendal), the Mediterranean fruit fly (Ceratitis capitata (Wiedemann)) and the melon fly (D. cucurbitae Coquillet). The use of protein hydrolysate bait-sprays for the Mediterranean and other fruit flies also represents a major advance in control of fruit flies.

21. Another major advance in the insect-attractant field has been the identification of the chemical structure and synthesis of the male sex attractant present in the virgin female of the gypsy moth (Porthetria dispar (Linn)). Similar research on the insect and on biochemical aspects of sex attractants would seem to offer most promising fields of investigation.

22. The development of the sterile-male concept of insect control has been applied successfully for the eradication of the screw-worm (Cochliomyia hominivorax (Coquerel)), a major livestock pest, from the southeastern United States. The method involves the production and release of a large number of sterile insects. Research is underway to explore this approach for the control of tropical fruit fly species, the pink bollworm, the boll weevil, codling moth (Carpocapsa pomonella (L.)) and the tobacco hornworm (Protoparce sexta (Johannson). Two methods of producing sterility are under investigation--(1) by exposure to gamma radiation and (2) by exposure to chemicals.

23. Application of the chemosterilant method induces sterility in insects with less adverse effects on the vigor and competition in males than use of gamma radiation. The sterility principle promises a new approach which should apply to vertebrate as well as invertebrate pests. However, much research is needed on the autocidal approach to the control of invertebrate or vertebrate pests, whether it involves producing and releasing sterile organisms or inducing sterility in the natural population. The utilization of strong male sex lures and other attractants in insects and the application of chemicals that produce sterility now being developed offer two systems that, when combined, have the potential of producing maximum results in regulating insect populations.

Vertebrate-Pest Problems

24. In the control of vertebrate pests the target species often plays a dual role, being a destructive pest under some situations, but, under others, of value to human existence. In some parts of the world most of the birds and many species of mammals and fresh-water fish are protected and their populations maintained at the highest possible level, largely for the aesthetic and recreational values their presence offers. Although their contribution to the food supply may be appreciable, this benefit is not critical in providing an adequate diet for the people of these areas. On the other hand, in far larger areas of the globe, a handful of sparrows, a rodent from the field, or a carp from the irrigation canal will at times provide the only meat available to supplement a basic vegetable diet. Local populations of vertebrates that in one area can be sacrificed to protect some more valuable resource, such as rabbits in Australia, deer in New Zealand, ground squirrels and blackbirds by the millions in the United States, in another area must be repelled or taken in such a manner as to leave them suitable for consumption by humans or domestic animals. Even the lowly meadow mouse (Microtus), during years of abundance, has been laboriously captured and converted into animal feeds and soil fertilizers.

25. Presently known pesticides allow a versatility of materials for rodent control. It is possible to prepare highly attractive food baits or to effect control with a carrier no more critical than water. Some of these rodent poisons are both primary and secondary hazards to beneficial wildlife associated with rodents and the utility and safety of these poisons depends on their application by responsible well-trained

operators. Other rodenticides do not present a secondary hazard, and a few, when properly formulated, are quite specific for a narrow range of vertebrate species. Several of the toxicants provide a quick knockdown, but with others the onset of symptoms is delayed, a feature which confers a higher degree of control than would be possible when the death of one individual warns other members of a feeding group. When outbreaks of human disease make necessary the quick suppression of the rodent-vector, several of these rodenticides can be adapted for use as baits distributed by aircraft or mechanized ground equipment. Chemical rodenticides are known that are effective when applied as liquid sprays to field habitats, or even buildings. However, in either of the techniques that call for the toxicant to be blanketed over the habitat, complete freedom from adverse effects on associated beneficial species is not yet possible. Other rodenticides are effective as powders dusted into burrows or animal trails, or as pastes and foams smeared where they will be picked up on the feet and fur of the passing rodents. The effectiveness of most of these rodenticides is dependent on subsequent grooming by the animal and resulting oral ingestion, but several can cause death by being directly absorbed through intact skin. The phytotoxicities of most of the vertebrate pesticides are known so that is is possible to effectively protect seed from mammal and bird attack without adversely affecting germination or subsequent growth of the seedling. In fact, some new candidate rodenticides can be translocated from soil placement into the growing plant, thus creating a living toxic bait. Finally there are rodenticides that are effective as gases for the fumigation of burrows, stored food products, and buildings.

26. An important aspect of some vertebrate-control programs is the ability to control the ectoparasite at the same time. It has been shown that the incidence of disease in a plague area temporarily increases following control of rodents, since the disease vectors (fleas, lice) are literally forced to transfer to humans and domestic animals for a blood meal. Where it is possible to use gases such as cyanide, methyl bromide, or chloropicrin for the fumigation of rodent burrows, store food products, and infested buildings, control of ectoparasites is accomplished easily enough. When fumigation with gases cannot be employed, use of a chlorinated hydrocarbon insecticide as a tracking powder in connection with feeding stations, stocked with food that contains a slow-acting rodenticide, results in the rodent transferring the insecticide on its fur to its nest site before death. A promising solution, and the subject of much current research, is the use of slow-acting systemic rodenticides that eliminate the ectoparasites by circulation in the blood of the host prior to its death. Certain organic phosphates and carbamates appear useful in this regard.

27. The remoteness of an area, the economic status of its peoples, and the availability of technical instruction and assistance dictate that the widest possible approach be taken in the solution of vertebrate-pest problems. New methods for the control of vertebrates arise from many diverse programs in the United States. The dynamic synthesis programs of the agricultural chemical and drug industries provide experimental basic material at a rate that taxes facilities for biological evaluation. It has been estimated that approximately 2,000 new chemicals and drugs which are of "probable utility" can be made available each year for evaluation and development as vertebrate pesticides.

28. In research on entirely new compounds, emphasis is in the direction of the following: (1) More specific compounds, that is, materials that will eliminate a given vertebrate species with little or no adverse effect on associated beneficial life; (2) repellents for protecting agricultural crops, forest reproduction, and range browse plants against browsing by rabbits, porcupines, deer, and even domestic livestock; (3) certain chemicals particularly those that can be translocated into living seeds and plants to render them temporarily unpalatable during transplanting and initial establishment of the plant on the site; (4) chemosterilants having an effective period of 1 year for long-range control of mammalian predators and certain bird pests; and (5) anaesthetizing and stupefying compounds that can be used with baits to take vertebrates alive for further utilization or selection.

29. In addition to the many well-known rodenticides and vertebrate-control chemicals, a library of new candidate materials is growing rapidly. Seldom does the chemical per se have all the attributes of an effective pesticide. For example, a toxicant may prove to be ideal for a given purpose, with the exception that vertebrates will not voluntarily consume baits containing it. Rather exciting new formulation techniques now permit the masking of the taste, or effect the delay of the onset of warning symptoms by (1) microencapsulation, and (2) formation of inclusion compounds, "clathrates." Even some degree of safety can be built into the formulation by such devices as (1) the inclusion of emetics that have little or no effect on the rodent to be controlled but act quickly on children, domestic pets, and livestock that accidentally ingest the baits; or (2) the off-coloring of poisoned grains used in rodent control to deter birds from feeding thereon.

30. Many improvements in standard products have been made. For example, synergists have been found that permit effective use of rotenone in the control of trash fish at half the former amount needed per-acre foot of water. A new companion product to be incorporated with anticoagulant rodenticides promises to materially improve the control of house mice (Mus musculus). In another such product a change in solvent was found to increase the toxicity of the active ingredient many fold.

31. Mechanical means of vertebrate control are far from being outmoded in modern practice. The responses of birds to light of different colors and intensity, to amplified sound, to recorded distress calls, and to radar and associated electromagnetic fields are receiving intensive study.

32. Recently, tractor-drawn, hydraulic-controlled equipment for constructing subsurface tunnels or runways, called a "burrow builder," has been perfected for metering and placing poisoned baits in underground runways that intersect natural subsurface workings of the destructive pocket gopher (Geomyidae). Two goals are achieved: Control operations are more rapidly accomplished, and the placement of the poison bait avoids any hazard for domestic livestock and beneficial wildlife.

33. The trap, historically one of the first of man's tools in his competition with other vertebrates, continues to serve him, being found in every conceivable size and type, with a choice as to whether the animal is to be taken alive or dead, singly or in groups. A trap may be as simple as a fine-mist net stretched across the flight path of birds; a light-to-carry, easy-to-set loop snare, to replace the burdensome steel trap for taking bear (Euarctos); or at the other extreme, a collapsible, barn-sized trap equipped with flood lights to attract birds by the thousands when flushed from their roosts at night.

34. The problems of pest control as they relate to food production and public health merit international effort and cooperation. The United States is willing to share its knowledge in the technology of management of pest populations together with new information as it evolves from an extensive research and development program.

Table I

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Major types of insects involved in crop production in the United States and some of the more commonly used insecticides employed for their control

Crop Pests	Insecticides Employed	Remarks
Cotton insects	DDT, toxaphene, dieldrin, endrin, BHC, calcium arsenate, Guthion, methyl parathion, malathion, Aramite, demeton, carbophenothion, sulfur, Sevin	
Vegatable insects	DDT, malathion, methoxychlor, toxaphene, rotenone, pyrethrum, Sevin, parathion, demeton, naled, Phosdrin, Guthion, endosulfan, diazinon	Careful attention to dosage, formulation, and timing of treatments in relation to harvest must be observed in order to aviod residues or to meet tolerances
Corn, rice, sorghum, and small grain insects	DDT, toxaphene, methoxychlor, dieldrin, endrin, Sevin, parathion, diazinon, naled, malathion, Phosdrin	Same as above
Fruit insects	DDT, methoxychlor, lead arsenate, rotenone, Sevin, malathion, parathion, Guthion, diazinon, EPN, demeton, endosulfan, Aramite, ethion, carbophenothion, Tedion, Kelthane, ovex	Same as above
Legume and grass insects	DDT, methoxychlor, dieldrin, aldrin, heptachlor, lindane, toxaphene, parathion, demeton, malathion, Phosdrin, naled, diazinon, Sevin	Same as above
Sugarcane and Sugar beets	parathion, demeton, Dylox, naled, phorate, DDT, carbophenothion, endrin, ryania	Residue problem may be critical if beet tops are used as animal feeds
Tobacco insects	TDE, endrin, Guthion, endosulfan, parathion	Bacillus thuringiensis, var. thuringiensis, an insect pathogen is used for tobacco hornworm and bud worm control
Soil insects	Aldrin, dieldrin, heptachlor, chlordane, DDT, diazinon	

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SUMMARY

Agenda Item: C.4.2

United States of America

PROTECTION FROM INSECT AND VERTEBRATE PESTS IN RELATION TO CROP PRODUCTION

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Protection From Insect and Vertebrate Pests in Relation to Crop Production

by
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SUMMARY

1. Insect and vertebrate pests represent major obstacles to agricultural production, and methods for their control ar necessary for an efficient agricultural economy. However, many kinds of insects and vertebrates are highly beneficial and are needed to maintain a reasonable balance between the destructive and useful organisms. Chemicals now provide the chief means of controlling insects affecting crops in the United States. A wide variety of material is available, including DDT, methoxychlor, lindane, toxaphene, aldrin, dieldrin, heptachlor, endrin, parathion, malathion, Guthion, Phosdrin, naled, demeton, phorate, diazinon, Sevin, pyrethrins, rotenone, and ryania. These insecticides and others have been responsible for substantial increases in yield and improved quality of many crops. However, the extensive use of insecticides has necessitated special research and careful selection of insecticides and methods of use to avoid residues on crops or to meet tolerances. The side effects on beneficial insects and fish and wildlife have also posed problems that are being given greater attention in research. Other methods of insect control utilized in the United States include cultural practices, importation and establishment of parasites and predators, development of crop varieties resistant to insect attack, use of insect attractants and baits, development and use of insect pathogens, and the use of the new autocidal sterile-male procedure.

2. Research on insect control is emphasizing the development of chemicals that leave no residues; the integration of insecticides and biological-control agents; greater use of bacteria, viruses, fungi, and other pathogens; parasites and predators for controlling destructive insects; the development of crop varieties resistant to insect attack; and the development of the sterility procedure. The research on the sterility principle involves both atomic radiation and chemicals that produce sterility in insects. The discovery of the nature of the chemical in virgin females which attracts the males of the gypsy moth has opened a new line of research on attractants highly specific in action for other insects. The use of attractants and sterility agents provides possibilities for improving insect-control methods.

3. Advances in regulating vertebrate pests which damage crops have been substantial. Highly effective chemicals, some of which are quite specific for a narrow range of vertebrate species, areavailable for controlling rodents. Certain toxicants give quick knockdown; others cause a delayed effect. Some materials may be used in baits and distributed by aircraft or mechanical ground equipment. Others may be applied as liquid sprays to field habitats. When toxicants are blanketed over the habitat, complete freedom from adverse side effects is not yet possible. Research on chemicals for regulating vertebrate

pests is emphasizing chemicals that are specific in toxic effect on the pest to be controlled, on repellents, on chemosterilants, and on anaesthetizing compounds. Mechanical means of vertebrate control also under investigation include studies on the responses of birds to light of different colors and intensity and to amplified distress calls. Plant-breeding investigations designed to develop crop varieties which ripen early and thus escape bird migrations, the development of favorable growth characteristics such as tight shucks on corn (Zea maize), and other favorable characteristics, are also being undertaken. Improvements in traps, one of man's first tools in his competition with other vertebrates, are also being made.

4.. Scientists in the United States are prepared to share with other scientists throughout the world the new developments in research that offer ways to deal with different invertebrate and vertebrate pests. Many opportunities exist for the exchange of information and materials that can lead to more rapid and efficient systems for dealing with these competitors for food and other essential agricultural commodities.

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Agenda Item: C.8.1

United States of America

OCEAN FISHERY PRODUCTS AND THEIR INLAND TRANSPORT IN LESS DEVELOPED AREAS : A MULTI-DISCIPLINARY APPROACH FOR DELIVERY OF PROTEIN FROM THE SEA TO THE INLAND CONSUMER

By Dr. Wilbert M. CHAPMAN,
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OCEAN FISHERY PRODUCTS AND THEIR INLAND TRANSPORT IN LESS DEVELOPED AREAS

(A multi-disciplinary approach for delivery of protein from the sea to the inland consumer)

by

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1. Large segments of the world's human population suffer continously from hunger and disease resulting from a severe dietary deficiency of animal protein. This is a serious condition that persists despite the fact that most of the protein-starved population centers are located in coastal regions to which the living bounty of the sea is available. Existing fishery resources off Southern Asia are only partially exploited and deep-sea fishing in the Arabian Sea, Indian Ocean, Bay of Bengal, South China Sea and the open Pacific is limited. In general, the harvest of fish in areas where protein starvation is greatest does no more than supply local demand; the actual yield falls far below the capacity of the stocks of fish and shell-fish that extend beyond the shore. What can be done to increase utilization of the many varieties of available marine food, to improve fish handling and processing facilities, and to provide efficient transport of fish protein to isolated inland markets? The purpose of this paper is to present a systems approach to what is essentially a complex interdisciplinary problem of supplying animal protein from the sea in the right form to the right place, and at reasonable prices.

Representative Problem Areas

2. Peru. For centuries, the ocean's wealth off the coast of Peru lay largely untapped by man. Aside from providing a meager subsistence to settlers on the shore, the sea's main contribution to human welfare was the fertilizer produced by seafowl who feed on marine life. In the past fifteen years, however, Peruvian fisheries have undergone a remarkable change. Production has increased from less than 50,000 metric tons in 1948 to more than 6,000,000 metric tons in 1962, and the end is not in sight. A fishing fleet of 1,000 modern mechanized vessels has been built, and more than 100 factories established for the processing of marine products. Expansion proceeds at such a rapid rate that there is actually a shortage of netting with which to equip the new ships.

3. This spectacular growth of the fishing industry has been a boon to the entire Peruvian economy. Fish products are now a major source of foreign exchange for the country, and thousands of workers have been employed in coastal regions that formerly

provided a marginal existence. Nevertheless, the precarious nutritional condition of several million people in the Andes, a short hour's airplane flight from port areas, has not been ameliorated significantly by the productivity of the sea. Some understanding of this seeming paradox can be gained from an examination of the following factors: (a) Implicit in the modernization process were ideas which required a long germination period before political and economic obstacles could be overcome and beneficial results obtained. (b) A substantial volume of the fish produce is exported in the form of fish meal. (c) Adequate transportation systems do not exist for the distribution of fish products from major centers of fish production to Peruvian towns and villages in the interior. This lack of efficient transport into the hinterland makes marketing costs prohibitively high when measured against local purchasing power. (d) Certain principal species of fish available in large quantities in Peruvian waters, especially ancheveta, are not particularly suitable for human consumption without substantial modification to please long standing tastes and preferences. (e) Certain technological problems involved in the production of protein concentrates from fish remain to be solved before the full potential can be realized as a cheap, acceptable staple in the diets of very low-income people. (f) Public health information and services have not yet established a public awareness of the importance of fish consumption in protein-deficient areas.

4. The Peruvian Government and specialized agencies of the U.N. are attempting to raise nutritional standards, and it is hoped that the results of their efforts will find application in other countries where similar problems exist.

5. West Africa. A concentration of population and an endemic disease vectored by the tsetse fly, which renders the raising of livestock impractical, are found in the tropical rain-forest belt that roughly parallels the West African coast from Guinea to the Cameroons. In this area incomes are very low and much of the economic activity, geared to a tribal society, is on a marginal subsistence basis. In no other area of the world is debility from protein deficiency disease more widespread or devastating in its effect on the people and economic progress.

6. Incongruously, the sea area adjacent to this belt of jungle and wooded savannah is one of the richest in the world, abounding in the pelagic fishes most relished by the people ashore who desperately require their nutritive value. This exasperating paradox of fish-eating people, close to unharvested stocks, importing fish at high cost, and still suffering from chronic protein shortages, is well known to West African leaders who seek satisfactory solutions to this age-old problem. The considerations involved, however, are considerably different from those in Peru, and include the following salient factors: (a) The local fishing industry is mostly in the canoe stage of development, with the result that thousands of skilled fishermen are severely limited in their range of operation and are at the mercy of the vagaries of current, wind and season. This condition results in gluts of fish when they are close inshore and drastic shortages when the schools move offshore beyond the limited reach of the fishermen. (b) The level of education, lack of technological development, and problems of transportation make it extremely difficult to accelerate badly needed improvements in fishery management and development. (c) The hot, humid climate causes high spoilage and greatly increases the problems of fish storage, transport and distribution, limiting the catch generally to immediate use in the landing area. (d) An extensive dried and smoked fish industry exists, but 25 to 50 percent of the product is destroyed by beetle larvae infestation. (e) Sociological factors must be carefully considered before attempts are made to modernize fish catching, processing and distribution. What would be the effect, for example, of the introduction of modern purse seiners on the social and economic life of coastal tribes?

7. Although it is known that marine resources are abundant in the Gulf of Guinea, fishery development has been impeded generally by a lack of knowledge of the relationships between ocean conditions and availability of commercially valuable aggregations

of fish. Oceanographic research conducted in the Gulf of Guinea and elsewhere in the Tropical Atlantic in the next two years should provide valuable guidance on improving the capabilities of harvesting fishery resources off the coast of West Africa.

8. India. In India a still different situation exists. Transportation facilities are generally superior to those of Peru or West Africa, and a higher level of technological skill is identified with the development of marine resources. Moreover, both seacoasts have abundant fish populations, especially the Indian Ocean. Yet we find the familiar pattern of a limited use of sea resources and widespread protein deficiency among the human population. Again we inquire: Why this particular anomaly in the midst of plenty? In India, the following factors are of major importance in the expansion of fish production: (a) The present government tends toward the philosophy that natural resources should not be exploited for personal gain. Therefore adequate profit incentives are not present to attract men and private capital into the risky venture of high sea fisheries. (b) Social traditions and religious beliefs engender negative attitudes towards both fishing as a means of livelihood and the acceptance of fish products for human consumption. (c) The lack of adequate harbors limits modern fishing vessel operations.

9. Southeast Asia. The coastal people of Southeast Asia are excellent fishermen who benefit from their long shore lines and plentiful supplies of fish. The inhabitants in general enjoy a strong fish flavor with their bland rice diet, and few social or religious beliefs bar the development of domestic fisheries. Although the fishing industry of the area has profited extensively from technical assistance from the U.N. (FAO) and other agencies, the vast majority of the people still do not receive animal protein in amounts adequate to supplement what is a predominantly vegetable diet.

10. Characteristic of the area are the familiar tropical problems of low-income consumers and a hot, humid climate that quickly spoils fish. The outstanding obstacle to a fuller use of fisheries is the almost total lack of facilities to transport fish products inland to dense population centers. The landings from small-scale fisheries typically are scattered over long stretches of the coast. Without an efficient transportation system, the costs of systematically collecting, processing, and marketing fish for inland distribution would be prohibitively high. The critical consideration in this instance is not simply that of providing new boats and gear to various fishing communities, but of bridging the distance between a landing and a hill village that may be only 10 miles away.

Requirements for Accelerated Development

11. The similarity of symptoms in these low-income areas masks a wide variety of underlying causes. There is no single magic formula for increased economic utilization of marine resources in coastal and inland areas since there is no single set of problems to be overcome. What is required is a unified method of analyzing the barriers to fishery development, and recognition of the need for biological, technological, economic, and engineering skills in fitting the several needs into a consistent, balanced program.

12. One road to fuller utilization of marine resources is to build, piece by piece, on the existing industry incorporating new technical processes and marketing methods in a program geared to the overall modernization process. It is a sound procedure but a slow one, and it drives home the fact that any expansion in the output and market outreach of fish is purchased only at the cost of lower production of other goods from which capital and skilled training are diverted.

13. The trade in fish is far from stagnant in these countries. Fresh, smoked, and dried fish move through well-developed small trader channels, and dried fish are handled in rather large volume. But at every stage the industry urgently needs modernization. Larger powered vessels are needed to handle modern gear and equipment. Processing losses and spoilage in the fish markets eat up an appalling part of the catch. Transportation routes and techniques are woefully inadequate, even for more durable commodities.

14. These areas are, in short, ready for change in their fishing and fish handling techniques. But the jobs to be done must be done simultaneously and with proper balance. The history of fishery development is littered with the wreckage of well-intentioned projects which did not take into account the impact of sudden increases in landings on inadequate transport, storage, and marketing facilities. Similarly, the introduction of modern technological methods in the various sectors of the fishing industry cannot be viewed apart from the total economic and social environment of which they are a part. Overall economic growth involves new industries and population concentrations and thus new targets for fishery products. Expansion in the use of fisheries is a complex matter of technological, organizational, and educational change that must be properly timed and analyzed to minimize economic and social costs.

15. To delve into the further complexities of sociological, religious, and political factors bearing on fisheries development would take us outside the scope of this paper. We cannot ignore them, however; if nothing else, technical and organizational improvements may create serious economic and social dislocation, particularly in nations still dominated by traditional modes of life. The pace of development must berelated to these considerations no less than to the direct costs of investment in new methods and facilities.

The Impact of Transportation on Fishery Development

16. Vital to the success or failure of fishery development programs is the degree of mobility and accessibility provided by regional and national transportation systems. Fishery projects and the speed with which they can be implemented to benefit protein-deficient populations are closely tied to the performance of existing port, terminal, inland waterway, road, rail and air transport facilities. Consequently, a detailed evaluation of the functional characteristics of the transport and distribution system must be an integral part of overall planning to promote maximum use of sea resources.

17. By bringing transportation into the planning process from the beginning, more rational choices can be made regarding the type, location and size of fish handling, processing and storage facilities, as well as appropriate methods of transport for fish distribution and marketing. The criteria for decision-making will need to take into account not only the relative cost and service function of alternative transport media, but other considerations relating to the volume of fish protein demand and supply by region, the restricted radius of markets, time in transit from producer to consumer, the demands for trained personnel, shipping hazards due to terrain or adverse weather, or the impact of different technologies on fishery and transport development. Countries of different sizes, topography, climate, and stages of economic growth obviously present a wide range of diverse problems and possibilities related to transportation and other major aspects of fishery development. In some areas, the relatively inexpensive extension of feeder roads to primary fish landings can bring extraordinary returns in the growth and concentration of marine fisheries. In other parts of the world, the use of inland waterways is a primary means of moving food supplies at low cost. In still others where difficult terrain hampers surface transportation, aircraft may effectively meet urgent consumer needs. But any attempt to arrive at physical and financial requirements for specific fishery projects must consider not only these interlocking relationships, but also the fact that existing organizational and administrative arrangements inevitably will condition transport services. Under the varying degrees of transport regulation, economic competition, and centralization, complex

problems will arise in the attempt to design an efficient transport network for delivery of fish products.

18. Particularly important are the advances in technology that will help reduce the drag of poor transport on fishery expansion. The new tools of systems analysis, conceptual mathematical models, and computer applications can extend the abilities of planners to analyze relevant data and predict the possible consequences of different courses of action. Interchangeable freight containers that can move through various types of carriers without breaking bulk from truck to rail, or rail to truck to barge offer possibilities for reduced cargo costs and greater protection of shipments against damage or adverse weather. Advances in the processing, preserving and storing of perishables could provide a wider dispersion of fish protein through the diminishing of peak load pressures on transport systems and the need for fast delivery. The development of mechanical refrigeration systems for trucks, trailers and container bodies has nearly eliminated spoilage losses in transit, and if the handling of frozen fish can be linked with the movements of other refrigerated commodities - meat, poultry and dairy products - the overhead costs borne by a fishing industry could be reduced. An example of this might be found in the Kenya-Uganda area of East Africa where a substantial traffic in frozen fish from the central lakes of Uganda and the coastal fisheries of Kenya inland to major population centers was made possible by a reverse flow of dairy products. Similarly, essential items such as nets, fuel and motor parts could be tied in to the carriage of non-refrigerated fish food. Changing technology can also have an impact in facilitating access to isolated areas through aircraft designed to take-off and land on short runways and configured to carry more cargo. Improvements in water transport efficiency may be realized through the introduction of diesel-powered tow boats and barges that can accommodate great volumes of freight at low cost. The potentials of transport innovations are thus essential ingredients of a total strategy for development and distribution.

Fish Protein Concentrates

19. Many of the marketing obstacles - the high cost of transportation and storage, the perishability and undependable quality of fish products - are directly related to the physical characteristics of traditionally processed marine foods. Similarly, processing limitations are at least partially responsible for the periodic gluts and scarcities so characteristic (and so discouraging to development) in the fish markets. Can more satisfactory processing methods be found which will yield safe, consistently uniform, high-quality protein concentrates from fish for use as supplements to deficient diets? If so, the impact on other essential operations in the flow of fishery products from sea to consumer would be immensely favorable. Elimination of the preservation bottlenecks would permit the harvesting of virtually all species of fish on a non-selective and less seasonal basis with significant increases in the physical and economic efficiency of fishing vessels and gear. Spoilage losses from hot, humid weather and infestation could be controlled at far lower costs, and basic market functions of transport, storage and retailing simplified considerably through obvious reductions in bulk and perishability. The overall effect would be a far wider dispersion of greater volumes of fish protein in diet-deficient areas.

20. Is the pursuit of this processing goal a dream, many years from solution? The authors do not think so. True, it appears at present that wholly flexible processes do not exist that result in fish products to suit all possible tastes and preferences. Yet we feel confident that the production of a safe and simple fish supplement which will be within the buying power of most low-income consumers is reasonably close at hand.

21. Today more than 20 nations are interested in the search for satisfactory fish protein concentrates. The Canadians have developed a product of exceptionally high

nutritive quality. The Union of South Africa has developed and tested a fish protein concentrate. UNICEF has actively cooperated with the Chilean government in the study of processing fish concentrates and a pilot plant is in operation. Researchers in other countries - Uruguay, Morocco, India, Russia, Norway, Sweden, Denmark, and Britain - also are actively engaged in the pursuit of satisfactory fish preservation methods. In the United States private industry has long been conducting processing studies, and the U.S. Government contemplates an extensive review of the problems associated with fish protein concentrate manufacture and use.

22. It should be repeated that the development of fish protein concentrates need not, and probably will not replace other methods of processing. There is, after all, no reason why individual tastes for fresh, dried, or canned fish cannot be satisfied. What is important is the stabilization of the overall market, the expansion of fishing effort which might be expected, and the extension of the dietary benefits of marine resources to areas and population groups otherwise hopelessly out of reach. The concentrates will present packaging, marketing, and consumer education problems of their own, of course, but they would raise far fewer problems than those encountered in expanding utilization of existing types of end-products.

Conclusions

23. In this discussion, it is implicit that the scale of any fishery development program must be closely tied to the existing resource base - human and physical - of the nations involved. Thus, a total strategy is required which will permit the accelerated use of marine food reserves but without incurring unnecessary or excessive allocations of scarce national resources. Regardless of the path chosen - building upon the traditional industry or introducing revolutionary change, or some combination of the two - the many critical factors which interact and constrain each other in fishery development require a broad-based, integrated approach to ensure their phased growth both as a systematic whole and in relation to the overall growth of the economy and society.

24. Today, the less developed countries are in a position where a rational choice can be made about the wide range of technological achievements available to them simultaneously rather than in a historical sequence as was the case in Europe and the United States. Scientific research has provided a better understanding of the distribution and movement of desirable fish species and improved techniques for their harvesting, processing and distribution. The future undoubtedly will bring many new improvements in the full use of the sea. Despite these advantages, a note of caution in the pace of development is suggested by the scarcity of reliable statistical data in most of the low-income countries, and the many examples of application of inappropriate technologies to emerging economies. Concern for the totality of the development problem is required to adapt scientific knowledge and techniques to the needs and aptitudes of a non-technological culture.

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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

C O R R I G E N D U M

Page 3, paragraph 8, line 4, change : "Indian Ocean"
to "Arabian Sea".

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NOTES

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OCEAN FISHERY PRODUCTS AND THEIR INLAND TRANSPORT IN LESS DEVELOPED AREAS

(A multi-disciplinary approach for delivery of protein from the sea to the inland consumer)

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SUMMARY

1. Many of the protein-starved areas of the world are located in coastal nations to which the living bounty of the sea is available. Yet these countries harvest only a relatively small percentage of their offshore fishery resources, primarily for immediate local consumption, while large segments of their burgeoning populations suffer continuously from a severe dietary deficiency of animal protein. What can be done to increase use of the many varieties of available marine food, to improve fish handling and processing facilities, and to provide efficient transport of fish protein to isolated inland markets? This paper suggests that a systems approach is required to what is essentially a complex interdisciplinary problem of supplying animal protein from the sea in the right form to the right place, and at reasonable prices.

2. Factors considered of major importance to the expansion of fishery resources in Peru, West Africa, India, and Southeast Asia are discussed.

3. At every stage the fishing industry urgently needs modernization. Larger powered vessels are needed to handle modern gear and equipment. Processing losses and fish spoilage account for a large proportion of the catch. Transportation routes and techniques are inadequate even for more durable commodities.

4. The similarity of symptoms in these representative areas masks a wide variety of underlying causes. There is no single magic formula for increased economic utilization of marine resources in coastal and inland areas since there is no single set of problems to be overcome.

5. One road to fuller utilization of marine resources is to build, piece by piece, on the existing industry, incorporating new technical processes and marketing methods in a program geared to overall modernization. Technical and organizational improvements in fisheries, however, may create serious economic and social dislocation, particularly in nations still dominated by traditional modes of life. Thus, the pace of development must be related to the sociological, religious and political factors of a less developed area.

6. Vital to the success or failure of fishery development programs is the degree of mobility and accessibility provided by regional and national transportation systems. Fishery projects and the speed with which they can be implemented are closely tied to the performance of existing transport facilities. Transportation, therefore, must be brought into the planning process from the beginning before rational choices can be made concerning the physical and financial requirements for specific fishery projects.

7. Particularly important are the advances in technology that will help reduce the drag of poor transport on fishery development. These potentials for transport innovations are essential ingredients of a total strategy for fishery development.

8. The development of safe, consistently uniform, high-quality protein concentrates from fish can have a considerable impact on other major aspects of marine food development and distribution. Spoilage losses from hot humid weather and infestation could be controlled at far lower costs, and basic market functions of transport, storage and retailing simplified considerably through obvious reductions in bulk and perishability.

9. Regardless of the path chosen -- building upon the traditional industry or introducing revolutionary change, or some combination of the two -- the many critical factors which interact and constrain each other in fishery development require a broad-based, integrated approach to insure their phased growth both as a systematic whole and in relation to the economic and social setting.

10. Although the less developed countries have a wide range of technological achievements available to them, concern for the totality of the development problem is required to adapt scientific techniques to the needs and aptitudes of a non-technological culture.

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Agenda Item: C.4.2

United States of America

BASIC PRINCIPLES IN WEED CONTROL AND THEIR IMPORTANCE IN CROP PRODUCTION

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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BASIC PRINCIPLES IN WEED CONTROL AND THEIR IMPORTANCE IN CROP PRODUCTION

by

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1. From the time man started cultivating crops, energy was required to control weeds. The first effort was pulling them out of the soil by hand. Then various tools were developed to make the hands more efficient. Man then developed cultivation tools that he or animals could pull through the soil. Farm tractors provided more power for cultivating crops, and facilitated great advancements in weed control. Mechanical methods in combination with good agronomic practices, such as use of weed-free crop seed, proper crop rotation, fertilization, and other production practices, are essential to effective weed control.

2. The sequence of events that occurs in plant successions when native vegetation is disturbed or cultivated fields are abandoned has been established in many parts of the world. Weeds and other types of undesirable vegetation comprise early stages in plant successions that terminate in the climax vegetation. This vegetation will not supply the food and fiber required by the world's population. The control of weeds is a basic, essential, and important factor in reversing this fundamental ecological process (10, 11).

3. Production efficiency, crop quality, and yields are greatly increased by the use of effective cultural, mechanical, chemical, and biological practices to control weeds. Choice of a method or combination of methods of control depends on the crop, weed population, climate, soil, topography, and economic feasibility.

4. The discovery of the herbicidal value of 2,4-dichlorophenoxyacetic acid /2,4-D/ in the early 1940's showed that chemical energy could be applied to weed control and led to evaluating the herbicidal properties of literally thousands of chemicals. As a result, instead of the only 3 or 4 herbicides of commercial significance in 1945, more than 100 organic chemicals are now in use as herbicides. These advances in herbicide technology resulted from the close cooperation of scientists of many nations.

5. Biological control of weeds by insects and diseases has not received adequate attention. Outstanding examples of biological control of weeds with insects include the control of prickly pear cacti (Opuntia spp.) in Australia and Hawaii by Cactoblastis cactorum, and the control of Klamathweed (Hypericum perforatum) in California, Oregon, and Washington by three beetles (Chrysomela spp.) (3,4,7). Research in this area is being expanded. At present several candidate insects are being evaluated for their specificity to certain weeds and the results to date are very promising.

CONTROL METHODS AND PRACTICES

6. The present trend in the United States is to use a greater variety of herbicides and to apply specific ones for controlling specific weeds in specific crops and specific areas. The new herbicides offer almost unlimited potential for selectively controlling weeds in most crops. A few examples of chemical weed control practices for field crops, for horticultural crops, on forage and rangeland, and for aquatics and on noncroplands will show the stage of development.

Controlling Weeds in Field Crops

7. Lowland rice is grown under conditions very favorable for growth and reproduction of terrestrial, semiaquatic, and aquatic weeds. Most weeds that infest rice

produce an abundance of viable seeds and once they infest the soil they are difficult to remove. The best approach is to prevent weed infestations by planting weed-free rice seed and to remove scattered weed seedlings before they produce seeds. If after the soil does become infested, the weeds may be effectively and economically controlled by cultural and chemical methods.

8. Rice growers control weeds chiefly by cultural methods. Adequate seed-bed preparation combined with judicious use of water is vital in a weed control program. However, even with the best agronomic practices some weeds are more effectively controlled by the use of herbicides. Broadleaved weeds and certain sedges in rice can be controlled with 2,4-D; 2-methyl-4-chlorophenoxyacetic acid (MCPA); 2,4,5-trichlorophenoxyacetic acid (2,4,5-T); and 2-(2,4,5-trichlorophenoxy) propionic acid (silvex). The reaction of rice seedlings to phenoxy herbicides depends on their morphological stage of development. Rice is least sensitive to post-emergence herbicides during the late-tillering stage, usually 7 to 9 weeks after germination.

9. A recently introduced herbicide 3,4-dichloropropionanilide (DPA), now commercially available, has proved highly effective for the control of barnyardgrass (Echinochloa crusgalli), other annual weed grasses and sedges, and broadleaved weeds in rice fields. This herbicide is used after the weeds emerge and is most effective on the weeds soon after they emerge (12). Rice is not injured by DPA at any stage of growth. In recent studies it was shown that the rate of application required to control barnyardgrass could be considerably reduced by adding a surfactant to the spray. In 1961, DPA was tested on 20,000 acres of rice by 400 commercial growers in five States. Reported gains as a result of treatment ranged from 325 to 5,300 pounds of rough rice per acre. The average gains reported in the five States ranged from 1,046 to 1,989 pounds (1).

10. Weeds differ in their response to different herbicides. Therefore, when several species are present in a rice field, mixtures of herbicides may be used advantageously.

11. Important advances have been made in developing improved cultural, mechanical, chemical, and combination methods of controlling weeds in sugarcane. The substituted phenylureas, s-triazines, phenylacetic acids, benzoic acids, phenoxyalkylcarboxylic acids, trichloroacetic acid (TCA), 2,2-dichloropropionic acid (dalapon), pentachlorophenol (PCP), and other herbicides can be used effectively on a large variety of weeds in sugarcane. Herbicides are applied as pre-planting soil-incorporated, pre-emergence, post-emergence, and lay-by treatments. These herbicides when combined with appropriate cultural practices will control a large variety of weeds in sugarcane.

12. Intensive efforts are being made to use chemicals to control weeds along fence rows, ditchbanks, head rows, and irrigation and drainage canals to prevent the reinfestation of sugarcane fields. Herbicides also are being combined with fallow plowing for the control of deep-rooted perennial species such as Johnsongrass (Sorghum halepense) and nutsedge (Cyperus rotundus). Choice of the appropriate herbicide, mixture of herbicides, rotation of herbicides, methods of application, and cultural practices to use for weed control in sugarcane and along fence rows, ditchbanks, head rows, and in the fallow portion of the rotation is greatly influenced by climate, soils, weed population, and a wide variety of cultural practices which differ greatly in the various sugarcane production areas.

13. For nearly 50 years herbicides have been used on Hawaiian sugar plantations. In 1960, Hawaiian sugarcane producers spent more than 7 million dollars for herbicides and their application to control weeds. Even though the per acre cost of weed control in sugarcane was high, the increased yield resulting from this practice has proven to be profitable. The use of herbicides in sugarcane has greatly reduced the amount of hand labor required to control weeds and resulted in higher yields and higher quality.

14. The ability to control weeds in corn by herbicides has been enhanced by the development of the s-triazines. These compounds incorporated in the soil before planting or applied pre-emergence after planting provide weed control for 4 to 8 weeks, which gives time for the crop to become established. In many of the lowland Tropics the climatic pattern of dry periods followed by rainy periods determines whether modern machinery can be used to control weeds. Corn is planted at the beginning of the rainy season. The problem is to get the corn to germinate simultaneously with the weeds. Generally, preparing land for corn planting before the first rains is a waste of time, because the first rains may not provide enough moisture for corn germination but are sufficient for the weeds to start. So by the second rain weeds are so abundant that land preparation must be repeated. The rains may then be so frequent and the land becomes so wet that adequate mechanical cultivation for weed control becomes impossible. A pre-planting application of one of the s-triazines which could be incorporated into the soil at the end of the dry season should be investigated. When the rains start weeds would be controlled, and the corn could be planted by any method available. Abundant growth of grass when corn is in the early stage of growth reduces yield.

15. It is estimated that losses from weeds in cotton production exceed 440 mill-

ion dollars each year in the United States. The development of improved chemical-cultural methods of weed control in cotton has greatly improved the efficiency of production. Herbicides are applied as pre-planting, soil-incorporated, pre-emergence, early post-emergence, and lay-by treatments in combination with various cultural practices for full-season weed control in cotton. Ethyl N,N-di-n-propylthiolcarbamate (EPTC) as a pre-planting, subsurface soil-incorporated treatment has proved effective for the control of such perennial species as nutsedge and Johnsongrass, as well as a number of annual broadleaved weeds and weedy grasses. 3-(3,4-dichlorophenyl)-1,1 dimethylurea (diuron) as a pre-emergence treatment has also proved highly effective for the control of most annual weeds in cotton production, but is not effective in controlling deep-rooted perennial species. Herbicidal oils are widely used as early post-emergence treatments for the control of annual weeds that are not controlled by pre-emergence treatments.

16. Recent research has resulted in the development of residual type herbicides which may be applied as directed post-emergence treatments that will kill emerged weeds and possess enough residual activity to prevent the emergence of late-season weeds. Herbicides such as diuron, 2,4-bis(isopropylamino)-6-methylmercapto-s-triazine (prometryne), and combination treatments such as diuron plus surfactant and N-(3,4-dichlorophenyl) methacrylamide (DCMA) plus disodium monomethylarsonate (DMA) applications have proved effective as directed post-emergence sprays and as residual treatments at lay-by. When these herbicides are used in conjunction with thorough seedbed preparation, mechanical hill dropping to a stand, cross cultivation, and shielded and unshielded cultivation, full-season control of most weeds can be obtained in cotton production. Studies on the cost of controlling weeds in the United States have shown that is costs an average of $20 per acre for hand hoeing and other conventional methods of weed control requiring an average of 27 man-hours per acre, as compared to a cost of $13 and 12 man-hours per acre using combination chemical-cultural methods. These studies indicate that cotton producers can save approximately $5 to $10 per acre and reduce the number of man-hours required for weed control by one-half if chemical methods of control are used instead of conventional methods.

17. In the production of small grains such as wheat, oats, barley, and rye, weeds cannot be controlled effectively by mechanical methods. Adequate labor for hand weeding in these crops in the United States is not available and would not be practical. The phenoxyalkylcarboxylic acids such as 2,4-D; MCPA; 2,4,5-T; silvex; and 4-2 (2,4-dichlorophenoxy)butyric acid [4-(2,4-DB)] have proved highly selective and effective in controlling broadleaved annual and many perennial weeds in small grains.

18. The phenoxy herbicides are usually applied at the full-tiller stage of growth for maximum effectiveness in controlling weeds in small grains. Some of these herbicides often are used also as pre-harvest treatments to control weeds as an aid to mechanical harvesting of small grains. The recently introduced herbicide 4-(2,4-DB) is the best known phenoxy compound that can now be used for the control of weeds in small grains underseeded with legumes on more than 35 million acres of cropland in the United States (9).

19. Since 1947, more than 200 million acres of small grains have been treated with 2,4-D or related phenoxy compounds, increasing the yield of small grains by more than 800 million bushels of grain (8). The average cost of the herbicide and its application is about $1.75 per acre. Yield and quality losses have been reduced from approximately 20 to 13 percent of the value of the small grains, while the use of the phenoxy compounds has reduced the cost of weed control in these crops by more than 50 percent.

Controlling Weeds in Horticultural Crops

20. The control of weeds continues to be one of the most critical production problems in horticultural crops. Weeds in the row cause serious problems in many horticultural crops. Mechanical weeding equipment cannot be used effectively because of the proximity of the weeds to the crop plants. Much hand labor was used to remove these weeds in the past, but such labor is no longer available in many areas. Therefore, effective economical control of weeds must now depend largely on development of new and improved herbicides and techniques.

21. Selection of effective herbicides and cultural and mechanical methods of weed control for horticultural crops is highly complex, partly because of the large number of plant families, genera, species, and varieties involved. Some vegetable crops that formerly required 100 to 200 man-hours of hand weeding per acre can now be weeded chemically at less than one-tenth of the cost. For example, pre-emergence applications of a combination of 2-chloroallyl diethyldithiocarbamate [CDEC] and isopropyl N-(3-chlorophenyl)carbamate [CIPC] are used for controlling weeds in spinach, lettuce, broccoli, and several other important vegetable leaf, salad, and cole crops. Pre-emergence applications of 4,6-dinitro-o-sec-butylphenol [DNBP] effectively control weeds in sweet corn and beans. Weeds that emerge after the last cultivation of transplanted crops such as tomatoes, peppers, and sweet potatoes are yielding to new herbicides, thiolcarbamates, acetamides, and substituted benzoic acids among them. Weeds in asparagus,

a perennial crop which formerly required intensive cultivation and hand weeding, can be effectively controlled by 3-(p-chlorophenyl)-1,1-dimethylurea (monuron). Candad thistle (Cirsium arvense), a weed that threatened the pea-processing industry, was recently brought under control with 4-(2-methyl-4-chlorophenoxy)butyric acid [4-(MCPB)].

22. In fruit and nut orchards weeds that harbor rodents, insects, nematodes, and other disease-producing agents, and compete for moisture and nutrients are being effectively controlled with fortified aromatic oil emulsions, DNBP, CIPC, diuron, 2-chloro-4, 6-bis(ethylamino)-s-triazine (simazine), and dalapon selected and applied in accordance with the problem weed species.

Weeds and Brush Control on Grazing Lands

23. Brush is a problem on grazing lands, where the climate ranges from very arid to humid subtropical. In the United States brush infests 320 million acres of range and pastureland. This about equals the acreage used for cultivated crops but is only one-third of the total area that is grazed. Species that infest extensive areas include junipers (Juniperus spp.) on 76 million acres; mesquites (Prosopis spp.) on 70 million acres; sagebrushes (Artemisia spp.) on 96 million acres, and prickly pear on more than 60 million acres. Thus, a wide range of species are involved, and the problems in developing control methods are diverse. It has been estimated that brush control would improve grazing on 240 million acres in the United States.

24. Weeds, brush, and poisonous plants cause tremendous losses in pastures and rangelands throughout the United States. For instance, in one eastern Nebraska pasture over two-thirds of the total production of plant material consisted of unpalatable weeds. The 3-year average yield of dry matter was 4,200 pounds; of this 2,300 pounds was broadleaved weeds and 700 pounds weed grasses (5).

24. Weed losses are not limited to the reduction in palatable forage available to livestock. Losses also result from weeds that impart undesirable flavors to dairy products, cause injury to grazing animals by thorns and briers, abortion, abnormal fetuses and in some instances cause death of livestock. Losses in animal production caused by sublethal poisoning often go undetected. For instance, an unusual abortion problem in beef and dairy cattle grazing on unimproved lowland pasture in Wisconsin went unsolved for at least 50 years. Research showed that sublethal dosages of nitrate in the weeds caused the abortions. Spraying these weeds with 2,4-D solved the problem.

25. Good management of livestock is virtually impossible on rangeland extensively infested with large mesquite or other trees. Controlling the brush with modern herbicides and other techniques facilitates the "rounding up" of cattle, the regular inspection and treatment of herds for diseases and insect disorders, and orderly culling and marketing of excess cattle. Saving the losses from inefficient handling of cattle in brush often would pay for the cost of control.

26. Some species of brush are efficiently removed mechanically. Moderately mature stands of juniper can be controlled by "cabling" on favorable sites. In deep rock-free soils, "root-plowing" in preparation for reseeding the area to grasses controls many species of undersirable woody plants. However, more efficient and versatile methods are being developed. Millions of acres of weed- and brush-infested rangelands are successfully converted to productive grasslands by use of herbicides. Woody plants can be controlled by applying herbicides to the foliage, to the bark, through cuts in the bark, and to the soil.

27. On most extensive areas of grazing land, the herbicides are applied aerially to the foliage of the undesirable weeds and brush. Ranchers in the Southern United States kill blackjack oak (Quercus marilandica) and post oak (Quercus stellata) with 2 or 3 annual aerial spraying of 2,4,5-T. Where an understory of grasses persists, forage production is increased 2 to 7 times as much (2).

28. Most species of sagebrush can be controlled satisfactorily with a single application of 2,4-D. However, repeated spraying is necessary to control many woody plants. Usually a single aerial spraying defoliates the trees, but within a few years they are again a serious problem. Therefore, it is important to study each species and each climatic condition in developing recommendations.

29. Undesirable woody plants may be controlled effectively by applying herbicides to the bark at the base of the trunk. Esters of 2,4,5-T and 2,4-D dissolved in diesel oil or kerosene effectively kill many kinds of undersirable brush during any season of the year. Basal sprays are more effective on plants 4 inches or less in diameter than on larger thick-barked ones. If the plants have a thick bark it may be necessary to cut through the bark to the sap wood so that the herbicide can be applied to the cambium layer. Basal sprays are particularly adapted for use on scattered stands of trees or where a broadcast spray likely would injure plants in adjoining areas.

30. Herbicides applied to the soil as dry granules or as sprays can kill woody plants. Application of 3-phenyl-1,1-dimethylurea (fenuron) pellets at the base of alligator juniper (Juniperus pachyphloea) has given good control and is being adopted for control of scattered stands of this species.

31. Proper agronomic practices are critically important for brush control on rangeland and may be equally as important as finding herbicides or other methods of

killing brush on grazing land. There must be at least a moderate stand of desirable forage species where brush control practices are to be applied if seeding of new species is not contemplated.

32. In many areas in the United States experience has shown that grazing should be greatly reduced or deferred during 1 or 2 grazing seasons after brush control to allow the desirable grasses to thicken. The residual grass can be grazed during winter. Fertilization and seeding of forage species may be necessary where dense brush is controlled, because such a dense stand usually contains little residual grass.

Weed Control in Aquatic and Noncrop Areas

33. Aquatic weeds, bank weeds, and phreatophytes cause tremendous losses annually to crop production in the United States and many other countries. Aquatic weeds grow submersed in, floating on, or emersed from water in irrigation and drainage canals, in reservoirs, and in farm ponds. Bank weeds grow at the waterline or immediately above, with their roots extending into the saturated or moist soil. Phreatophytes grow along streams, canals, or reservoirs and on river flood plains and habitually obtain their water from the ground water table or the capillary fringe immediately above (13).

34. Floating weeds such as water-hyacinth (Eichhornia crassipes) may reduce the flow of water in canals as much as 40 percent while submersed waterweeds such as naiads (Najas spp.) and pondweeds (Potamogeton spp.) may reduce it as much as 97 percent. Reduced flow makes water levels high in canals and streams and results in flooding, seepage into adjoining areas, breaks in canal banks, greater losses from evaporation, and inadequate delivery of irrigation water to farms or inadequate drainage of water from farms. In addition, decreased velocity of flow caused increased sedimentation, which reduces carrying capacity and makes more frequent mechanical cleaning necessary (13).

35. Aquatic weeds such as cattails (Typha spp.) and phreatophytes transpire water from canals, reservoirs, and the ground water table into the air and thus reduce water supplies.

36. The traditional methods of controlling aquatic and bank weeds in the United States include hand cutting or pulling, mechanical mowing, chaining, dragging, or crushing. These methods are still in use in many areas but where extensive weed infestations are prevalent in areas of high labor cost, the hand and mechanical methods are slow and expensive and are being replaced by improved chemical methods.

37. Discovery and development of aromatic solvents for the control of submersed weeds in irrigation channels were among the first achievements. The use of xylene increased rapidly in the Western United States after 1952 and 580,000 gallons were used in 1957. The use of xylene in these States in 1962 for control of aquatic weeds resulted in more than a million dollar saving as compared with the cost of controlling submersed weeds by previously used mechanical methods.

38. Cattails may be controlled by spraying with a low volatile ester of 2,4-D in an oil-water emulsion for 3 applications per year over a 2-year period. Dalapon and 3-amino-1,2,4-triazole (amitrole) alone or in combination have also proved effective in controlling cattails.

39. New herbicides have been discovered in the United States that show promise of effective and economical control of aquatic weeds in reservoirs, ponds, and lakes without killing fish or other desirable fauna, and some of these may be more suitable than aromatic solvents for use in irrigation and drainage canals. The search for even safer herbicides is being intensified.

40. The chemicals most commonly used for selective control of broadleaved weeds and woody plants on ditchbanks and around reservoirs, ponds, lakes, and flood plains are 2,4-D; 2,4,5-T; silvex; and 2,3,6-trichlorobenzoic acid (2,3,6-TBA). The tolerance of weed species to these herbicides varies considerably. Amitrole and dalapon are used for selective control of troublesome perennial grasses and sedges. Mixtures of amitrole or dalapon with 2,4-D or other phenoxy herbicides are commonly used for control of mixed vegetation consisting of undesirable dicotyledons and monocotyledons. In many areas where the use of phenoxy herbicides is prevented or limited by the proximity to cotton, grapes, or other sensitive crops, spraying with aromatic oils or fuel oils often fortified with PCP or DNBP is used extensively for general control of ditchbank vegetation. Soil-sterilant herbicides such as the phenylureas, the s-triazines, the chlorates or borates, and mixtures of these are used only in canals and ditches and on banks where their use does not produce a soil-erosion hazard. Ordinarily such herbicides should not be used on steep banks especially those consisting of gravelly or sandy soils or in ditches with rapidly flowing water.

41. Pasturing canals and ditchbanks with sheep, goats, or other livestock is frequently the most effective, least expensive, and most profitable method of controlling and managing vegetation. Fencing the canal or ditch right-of-way or herding or tethering the livestock along the channel usually is necessary. Pasturing is especially effective and profitable in combination with seeding of desirable species of grasses and legumes that compete strongly with undesirable weeds.

42. Limited research on the competitive effects of weeds in reducing crop yields and quality show that the loss is about 13 percent of the value of the crops produced each year. In addition to the losses caused by reduced yields and quality, the average cost of weed control in crops in the United States each year averages about 14 percent of their value (6).

43. As the science of chemical weed control advances greater consideration must be given to the development of overall weed control practices on the farm as a farm unit rather than limiting the development of weed control practices to individual crops. Farmers must be encouraged not only to use chemical weed control in the current crop, but to place greater emphasis on supplementing this program by the rotational use of herbicides on all tolerant crops throughout the rotation, thus preventing undesirable shifts in the weed population, and avoiding an accumulation of herbicide residues in the soil.

44. Where there is an abundance of farm labor available the question can be raised as to the necessity or practicality of adopting chemical weed control methods. Would not use of such methods simply add to the pool of people not gainfully employed? It is true that modern chemical weed control practices do substantially reduce the need for farm hands to hoe weeds from crops. Farm people not needed for hand weed control, especially the younger ones, would then have time to acquire basic education commensurate with their potential. Modern agriculture requires the application of new and developing science and technology. Those not qualified to accept such advancements hinder the world's efforts to feed an everexpanding population. Waste of natural resources cannot be tolerated if the goal of abundant food, feed, and fiber is to be achieved. Weeds take nutrients and water from the soil and compete with the desirable crop plants for light. Thus, they reduce both quantity and quality of desired crop plants. Therefore, they must be controlled. This control can be effected by good agronomic practices: use of weed-free seeds; appropriate crop rotations; application of fertilizer or manure when needed; cultivation to control weeds by the methods available; use of herbicides where knowledge is adequate for their safe adaptation and where the environment dictates the use of methods other than cultivation.

45. The application of these new technological advances will be reflected in increased supplies of food, feed, and fiber products that will help meet dietary requirements and improve standards of living in the world.

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BASIC PRINCIPLES IN WEED CONTROL AND THEIR IMPORTANCE IN CROP PRODUCTION

by
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1. The native or climax vegetation in most geographical areas never has been and still is not an efficient or economical source of food for livestock and humans. In order to feed, clothe, and shelter the world's expanding population, it has been necessary to replace the native vegetation with more efficient plants and to manage them at high productivity levels. The control of weeds is a basic, essential and important factor in crop production practices.

2. Weeds interfere with crop production efficiency and cause yield and quality losses that amount to about 13 percent of the value of the crops. Added to these losses is the cost of control, which averages about 14 percent of the value of the crops produced. It has been estimated that in the United States the annual losses from weeds and the cost of control exceeds 4 billion dollars annually.

3. An understanding of the physiological and biochemical fate of herbicides in plants and soils has resulted in the development of revolutionary concepts of selective chemical weed control. Outstanding progress has been made in developing mechanical, cultural, biological, chemical, and combination methods of controlling weeds in crop and noncrop areas. Combination chemical-cultural methods of weed control are now being used commercially to increase mechanization and production efficiency in rice, sugarcane, small grains, cotton, sweet potatoes, beans, potatoes, and other crops, and on pastures and rangelands.

4. Weeds are a total farm liability and all crops are subject to their competition. Greater research emphasis is being given to the development of overall weed control programs on the farm as a farm unit rather than to an attempt to limit the development of weed control practices to individual crops. Herbicides should be used not only on the current crop but also on all tolerant crops in the rotation. It is a sound principle to rotate different herbicides on the same crop grown continously and to rotate different herbicides on all crops grown in the rotation. This practice prevents undesirable shifts in the weed population, avoids an accumulation of herbicide residues in the soil, and provides for the full use of chemical energy in combination with cultural practices for weed control.

5. Future progress will be determined largely by the discovery of selective, more efficient, safer, and more economical herbicides; an understanding of the effects of chemicals on plant growth and soils; ingenuity in combining chemicals with cultural practices; an understanding of the limitations of current weed control practices; the integration of chemical weed control methods into established crop production practices; the influence of chemical methods on present cultural practices; and the discovery of more efficient sources of energy for weed control.

6. The development of improved chemical weed control practices represents one of the most effective approaches to increased efficiency and lower cost mechanized crop production. The application of these new technological advances will be reflected in increased supplies of food, feed, and fiber products that will help to improve standards of living in the world.

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Israel

IRRIGATION PROBLEMS, PRACTICES AND ADVISORY WORK IN ISRAEL

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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IRRIGATION PROBLEMS, PRACTICES AND ADVISORY WORK IN ISRAEL

B y

M. Boaz, Head of Irrigation Field Service
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- - No man may waste a drop of water that another man may turn into bread.....(attributed to Brigham Young).

Throughout the world, huge and magnificent water projects for irrigation are designed and constructed at fabulous sums of money. Some of the best engineers and most experienced personnel are employed by government, public and private agencies to carry out surveying, investigations, planning, designing, construction and operation of such irrigation projects as dams, canals, pumping stations etc.

Both in developed and less developed areas the large projects attract the attention and sympathy of the state and the public, as ways and means by which the standard of living can be raised as a result of higher crop yields under irrigation, as compared with dry farming. However in many cases there is a sharp dividing line between the irrigation project which includes the main hydraulic features and between the system of water application in the field. The actual field irrigation is left to the farmer himself with the confidence and satisfaction that the task has been fulfilled, as long as the water has reached the boundaries of the farm in ample quantities and quality. The science, or rather the "art", of field irrigation is given little attention in funds and interest as compared with the effort put in the development of water resources and its diversion and conveyance to the field.

In many cases the discharge of canals and pipe lines exceeds 3 to 5 times the water requirements of plants, due to lack of reliable information of water consumption by plants and the uncertainty in determining and controlling the water application efficiency in the field. This, inturn involves greater and extra investments and expenditures in constructing the irrigation scheme. In other instances, mostly in cases of extreme water shortage, the irrigation system is sometimes so designed that it does not meet the field water requirements and a decrease in crop yield is expected as a result.

In most irrigated lands, some attention is paid and effort is made to advance the the science of irrigation in experimental stations. Although plant, soil and hydraulic scientists realize the importance and role which proper irrigation plays in the yield and quality achievements and in the long term conservation of soil to prevent salinity and water loging; only a small part of the knowledge and experience gained in the research stations is utilized by the planners and transferred to the farmers.

Irrigation in itself is only one of the agricultural factors which determine the yield level, but it is a very decisive limiting factor whenever water is applied in measure or when water is short.

In both cases water has to be applied intelligently in order to make the best use of it.

Experienced and good farmers throughout the world believe that "the more water the better" for almost all crops. After thorough examination of this conception it seems to me that its origin is in the usually low efficiency of water application in the field which involves larger amounts of water per application and more frequent irrigations as well.

There are two main categories of plants as far as the importance of irrigation is concerned. The first group consists of plants which can not grow or even exist under dry conditions without the addition of artificial irrigation. In our country these will be the evergreen subtropical plants such has citrus, bananas, avocado and the like. The second group consists mainly of field crops and fruit trees which can exist and grow even under dry conditions but their growth and yield level are dependent and are a function of the availability of moisture in the root zone.

The role of irrigation for the first category is to provide ample moisture in the root zone during the dry season needed to obtain the highest possible yields and best quality of fruit. The role of irrigation in the second category is more complicated in this respect, since it involves the economic consideration of the best allocation of water in order to obtain the highest net income per unit water.

In a given area, cotton can be irrigated two, three, four or five times during the season and in each case the yield per unit area may will be a function of the no. of irrigations. Thus, the plot receiving four or five irrigations will yield more than that of three irrigations and the plot receiving only two irrigations will probably give the lowest yield per unit area. However, if we have at our disposal only so much water per season and the developed land is not a limiting factor; a thorough analysis, based on experimental work and economic considerations, must be made in order to decide how many irrigations should each plot be given in order to obtain the highest income per the total amount of water at our disposal.

In our country which consists of arid and semi-arid areas we face some overall irrigation limitations which must be taken into consideration when developing new lands for irrigation.

(a) Shortage of water:

In order to supply the necessary agricultural products for the ever increasing local population and at the same time produce valuable agricultural products for export such as citrus; it is necessary to utilize all available sources of water. This is turn creates a problem of overall shortage of water both for the urban and the rural population. The individual farm or farmer is alloted only a given quantity of water per year according to the region, type of crop and size of farm. Irrigation norms for crops are established and water rationing is put into effect in almost all agricultural regions.

(b) High total cost of water:

Water is a very expensive commodity in our country. If we combine the price of water the farmer has to pay at the head valve and the amortization on irrigation installation and equipment, with the labor cost for irrigation - the cost of water may well amount to 0.10 I.L. per 1 m3 in most regions. If the average amount of water applied per Ha. per year is about 6500 m3, the total cost of water per Ha. would then be about 650 I.L. or app. $215. This high cost comprises a relatively high percent of the total production cost of many crops.

In citrus up to 15%
In cotton up to 20%
In ground nuts up to 25%
In corn up to 30%

(c) Soil, water and climatic limitations:

When developing a new area under irrigation the soil and water charachteristics must be checked and analysed and the selection of crops to be grown and irrigated must be considered accordingly.

It is very difficult both professiondly and economically to set up the proper lower or upper limits of soil, water and climatic charachteristics for optimal growth of commercial crops. The limits are usually set up arbitrarily, according to experiments and experience and farmers are advised on very careful irrigation management especially under the more adverse conditions.

With the expansion of citrus plantations also to the heavier soils, arbitrary limits for soil charachteristics were set and government loans were given only to plantations on soils which comply with these limits. Furthermore, careful irrigation management is being practiced in most of such groves to prevent water loging and root rot as a result.

The individual farmer or a group of farmers in their every day's work, face many and various problems of which irrigation as such is only a part and sometimes a very small part. The overall irrigation limitations described do not bother them to the same extent as they do the state, the various water agencies and the regional authorities. The actual daily irrigation problems which the responsible irrigator faces must be answered and worked out mostly during the course of the irrigation season itself. These actual daily irrigation problems can be listed as follows:

(a) Correct timing of irrigations
(b) Desired depth of wetting per each irrigation
(c) Amount of water required to wet a given depth of soil
(d) How to apply the required amount of water per each irrigation
(e) How to coordinate irrigation practices with other agricultural treatments
(f) How to overcome adverse soil, water and climatic conditions during the irrigation season.

In order that farmers will be able to answer the above requirements and solve irrigation field problems as far as field conditions permit, beforehand planning of water allocation and irrigation schedules should be attempted during the winter and early springs. Such systematic and thorough planning in advance, which takes all available information and previous experience into consideration, will largely facilitate the every day's and seasonal correct and efficient use of water. Farms have almost doubled their irrigated areas together with an increase in yields per unit area, without any increase in the total quantities of water, by correct planning and application of water.

An irrigation schedule of citrus is given here as an illustration of such, in advance planning:

The farm: Demonstration

The plot: Old citrus grove

Date of beginning of first irrigation: 15 April

Depth of layer: : - : - : - : Total available moisture at a depth of 0-100 cm

100% available moisture : : : :
m3/dunam/1cm depth : 1.4: 1.4: 1.4: 140 m3/dunam

Month	Lower limit of A.M. before irrig. %	depth of wetting cm.	100% A.M. at the depth of wetting m^3/d.	Daily (*) net addition m^3/d.	Intervals between irrigation days	Net amount of water per application m^3/d.	Irrigation No.	Irrigation date	gross (**) amount of water per application m^3/d.
Apr.	50	70	100	2.0	~~25~~	50	1	15/4	60
				2.5	25				
May	50	90	125	2.5	25	60	2	10/5	70
June	40-50	100	140	3.0	21	65	3	4/6	75
				3.5	21	65	4	25/6	75
July	40-50	100	140	4.0	20	70	5	16/7	80
Aug.	40-50	100	140	4.0	20	80	6	5/8	90
						80	7	25/8	90
Sept.	40-50	100	140	4.0	20	80	8	14/9	90
				2.5					
Oct.	40-50	90	125	2.5	25	60	9	9/10	70
						610		7000 m^3/Ha.	= 700

(* Daily net addition is the average daily amount of water actually added to the soil between successive irrigations.

(** Considering efficiency of irrigation at a rate of 85%.

The existing difference between the required amount of water to wet a given root depth and the applied amount, sometimes reaches 50% or more. For instance, instead of applying a net amount of 60 mm, the amount actually given can reach 900 m3/Ha.(90 m3/d.) and even then there is no guarantee that every spot in the irrigated area has received the required 60 mm.

Out of approx. 135.000 Ha (1350,000 d.) of the irrigated land in Israel, some 90% is irrigated by sprinkling. The following principal factors account for the fact that the method of sprinkler irrigation is so prevailing in this country:

(a) Sprinkling is usually the most efficient method of irrigation.

(b) The main development in agriculture in Israel has taken place during the last 15 years when sprinkler equipment of good quality was available.

(c) Sprinkler irrigation requires relatively little experience on the part of the irrigator and is adaptable to most topographical, soil and crop requirements and conditions.

(d) Sprinkler systems can be designed and constructed in a relatively short time.

(e) The topography of most irrigable land in Israel is rolling, therefore sprinkler systems which require little or no earth-work, are more suitable.

(f) Due to considerations of water distribution and metering, sprinkler systems are particurly suitable for small holder farms.

As a result of the extensive use of sprinkler irrigation throughout the country, the manufacturers of sprinkler irrigation equipment have specialized in this field, and by now all sprinkler equipment of good quality is being manufactured in Israel, both for local use as well as for export.

Whenever using sprinkler irrigation properly the amounts of water can be regulated and a high uniformity of distribution can be maintained. Under such condition application efficiencies of 75 - 85% can be achieved in practice. The gap between the required amount of water and the actual applied amount gets smaller every year due to better irrigation equipment which is being thoroughly tested before being issued into the market and due to better irrigation practice on the farm.

Conbined furrow and sprinkler irrigation systems are being practiced with success on increasing areas especially for cotton and corn irrigation. The labor requirements and the hard work involved in moving the portable sprinkler equipment in tall growing crops, call for improving the existing methods of irrigation and it is found that a combination of furrow and sprinkler irrigation is efficient in both respects as for as water use are concerned and labor. Usually the first two irrigations are applied by sprinkling and the rest, when the crop is fully grown, by furrows.

Most of the citrus and orchard irrigation in this country is irrigated by under-tree sprinkling. Recently, over the last two years, sprinkler systems with small diameter flexible plastic laterals have been introduced to a large extent into citrus groves and orchard plantations. There is a marked saving in labor and a better water distribution is accomplished with the use of such systems. The better quality of the plastic tubing is now emphasised in order to equal or surpass the life-time of the aluminium tubing used so far.

Mechanized sprinkler irrigation for low growing field crops has also been introduced in the last few years to increase the efficiency of irrigation labor.

A new method of sub-soil irrigation is being tried now in experimental and commercial plots with citrus and other fruit trees. If this method is proven successful as far as water distribution and salt accumulation are concerned the saving of water, as compared with overhead methods of irrigation, is said to amount to 30% or more.

The Israel Irrigation Field Service (I.I.F.S):

The Extension Authority of the Ministry of Agriculture maintains and operates 15 Irrigation Field Service Stations, cooperation on a 50 : 50 basis with all the agricultural District Councils throughout the country. Each Service Station consists of a staff of 3-6 field and laboratory workers and is equipped with a soil-water laboratory. The purpose of the I.F.S. is to assist farmers to improve irrigation practices and to conserve water while maintaining high crop yields. One of the duties of the I.F.S is to transfer to the farmers results obtained in the research stations and in the many controlled plots which the service field workers inspect closely throughout the growing season.

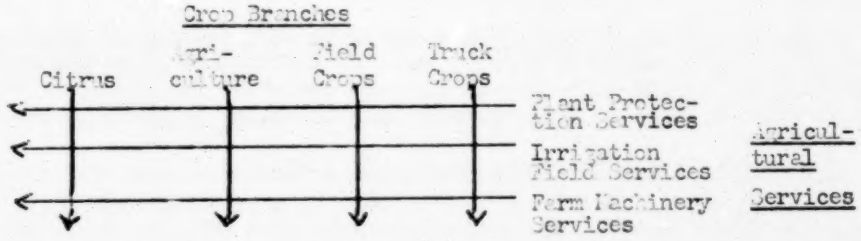
The I.F.S. is equipped to determine the pertinent soil and water characteristics of each farm, and use the information thus obtained in order to adapt the data produced by Research and checked in controlled plots, to the individual conditions of each farm. The I.F.S. has brought about the concept of irrigating according to soil, plant and climatic indicators with due regard to all other agricultural aspects. Each field worker

covers app. 2500 Ha, of irrigated land including all crops in private, cooperative and collective farms. The total cost of operating the I.F.S. in the districts is app. 10 I.L. per Ha., 50% out of which is shared by the farmers themselves through their District Councils and Agricultural Committees. Each of the I.F.S. stations has a district management consisting of representatives of the District Councils and Agricultural Committees and of representatives of the central and local staff of the I.F.S. The management assembles 2 - 3 times a year to draw the working schedules for the district I.F.S and to hear advance reports on the work done. The management also confirms the budget of the district I.F.S. at the beginning of each fiscal year and sees to it that the money is spent according to the endorsed budget. The organization of the I.F.S. is unique in this respect, since its budget is shared in equal parts by the government and the district councils.

The central staff of the I.F.S engages is specialized fields, namely: Orchard, Citrus and Field Crops irrigation, Sprinkler irrigation, Open irrigation, Soil and Water Problems and recently also in plant nutrition. At the central's staff disposal are a central laboratory equipped and able to perform all essential soil - water - plant tests and the Institute for Irrigation Methods and Equipment which carries out tests on newly developed irrigation methods and equipment.

The central staff of the I.F.S. carries out demonstrations and courses in the different subjects of irrigation and participates in demonstrations and courses of more general agricultural character. The main irrigation course is the course for Irrigation Technicians which lasts for over 3 months and is aimed mainly for irrigation supervisors in collective and cooperative farms. Three international seminars on irrigation were held by the central staff of the I.F.S. in cooperation with other research and water agancies and the F.A.O of the U.N.

The Irrigation Field Service is a part of the general Extension Authority of the Ministry of Agriculture and is one of its agricultural services which are given to farmers in all forms of settlements. The Extension Authority as such is composed of various branches, namely: Field Crops, Citrus, Orchards, Truck Crops etc. and agricultural services such as Plant Protection Service, Irrigation Field Service, Farm Machinery Service, Agricultural Economics etc. The interrelation between the branches and the services is best illustrated by the following diagram:



Since irrigation plays a major role in all crop branches and in the general economy of the individual farmers and the country as a whole; a great emphasis is put in the intensity of its service to the farmers. The I.F.S. is trying to utilize the best methods and equipment and use both local and world experience and knowledge, in order to render the best possible service. This can be achieved and is achieved only through the close cooperation with the farmers themselves and their representatives in the District Councils and in the Growers Associations.

The I.F.S. was established about 10 years ago in two districts only and has since spread to almost all districts in Israel. During its operation the I.F.S. helped to increase the efficiency of water use considerably and together with the farmers themselves and the general agricultural extension work which is carried out successfully in this country, has brought about an increase in crop yields per unit area and per unit water. And there is still much work ahead !

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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item : C.3.2 Israel

IRRIGATION PROBLEMS, PRACTICES AND ADVISORY WORK IN ISRAEL

By M. BOAZ,
Head of Irrigation Field Service,
Extension Authority,
Ministry of Agriculture

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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IRRIGATION PROBLEMS, PRACTICES AND ADVISORY WORK IN ISRAEL

M. Boaz,

Summary

1. The importance of irrigation

   a. Water consumption in relation to crop yields
   b. Income per unit area and per unit water

2. Overall irrigation limitations

   a. Shortage of water
   b. High cost of water
   c. High cost of labor
   d. High cost of installations
   e. Soil, water and climatic limitations

3. Actual daily irrigation problems

   a. Timing of irrigations
   b. Desired depth of wetting per each irrigation
   c. Amounts of water required to wet a given depth
   d. How to apply the required amounts of water per each irrigation
   e. How to coordinate irrigation practices with other agricultural treatments
   f. How to plan and organize the irrigation schedule
   g. How to overcome soil, waterand climatic problems during the irrigation season

4. Irrigation Practices

   a.Sprinkler irrigation
   b. Combined furrow and sprinkler irrigation
   c. Border irrigation
   d. Underground irrigation
   e. Agricultural drainage leaching practices
   f. Irrigation systems and equipment

5. Advisory work in Irrgation (The Irrigation Field Service)

   a. The regional Irrigation Field Services and laboratories
   b. The central soil-water-plant laboratory
   c. The Institute for Irrigation Equipment
   d. The central staff of the Irrigation Field Service
   e. Training, demonstrations and courses
   f. Coordination and Cooperation aspects

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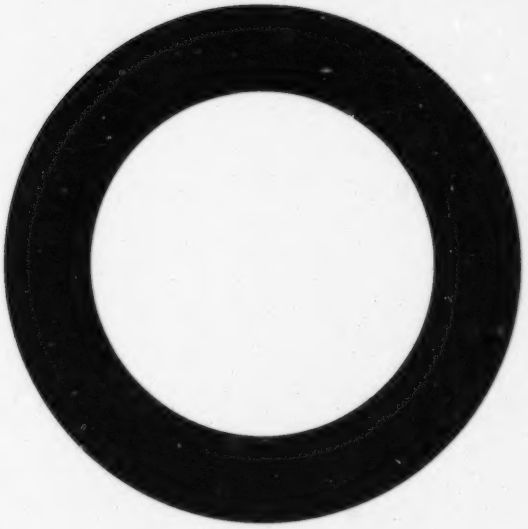

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Agenda Item: C.5.3

Bulgaria

THE DAIRY INDUSTRY IN THE PEOPLE'S REPUBLIC OF BULGARIA

By Professor Nikola DIMOV,
Director of the Dairy Industry
Research Institute

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326.
C.5.3.

THE DAIRY INDUSTRY IN THE PEOPLE'S REPUBLIC OF BULGARIA

Professor Nikola Dimov, Director of the
Dairy Industry Research Institute

The utilization of milk as food for man dates back to the remote past of human society. The economic and cultural development of the nations has gone hand in hand with the development of dairy farming until present day when it constitutes a major branch of agriculture, while the processing of milk became a very important industry. The favourable conditions of climate in Bulgaria provide excellent opportunities for the development of dairy farming, while the new economic structure of the country turned pooled the once small-scale dairy farms in the country into bigger and more efficient units.

It is beyond dispute that the development of the dairy industry is in the first place related to the development of milk-production. One of the specific features of milk-production in Bulgaria which inevitably affects the structure of the country's dairy industry, is the production of cow, sheep and buffalo milk, with the ratios among the three types changing constantly as a result of the growing production of cow milk. Whereas before the war the quantity of sheep milk whose production has a seasonal character accounted for 87 per cent of the total amount of milk processed in the country, this percentage has dropped to merely 24 in 1961. During the pre-war period, this feature of milk-production was a reflection of a particular type of milk-processing enterprises which were small, with no modern equipment, and operating on a seasonal basis. There were a total of 1,159 such small enterprises during this period, 662 of which were in private hands and 497 were co-operative. The average annual capacity of one of these enterprises was 63 tons. The principal dairy products obtained were the yellow cheese, known as Kashkaval, and the white brined cheese made of sheep milk. At that time Bulgaria possessed not one single mechanized enterprise dealing in the processing or supply of milk to the population. Milk was sold directly by the private farmers or by middlemen from the villages. The large number of people bringing milk into the towns made it impossible to exercise efficient control over the milk offered for sale on the market. That is why it was low-grade milk that was offered to the consumers as a rule.

The setting up of a big dairy industry passed through several stages after the war. During the first years the efforts were directed towards restoring livestock-breeding as a whole and towards organizing the milk-processing industry under public control. All dairy farms were reorganized on a co-operative footing and the supply of milk to the population was taken over by the

respective people's councils. The rapid increase in the quantities of milk produced made it necessary to set up a special enterprise known as the "Mlekokoop" at the Central Union of Co-Operatives which took over all milk-processing in the country. The beginnings were laid in this manner of a well-organized milk-processing industry in Bulgaria.

The general process of industrialization after the war led to the appearance of new industrial centres and to the rapid expansion of the existing ones, of their population respectively. The need to supply this population with fresh milk and dairy products called for the organization of modern enterprises which laid the foundations of the national dairy industry of today. The difficulties encountered during this period consisted in the first place in collecting and transporting the milk, this being done by a large number of small enterprises. The lack of suitable facilities to keep the milk led to deterioration in its quality and to a corresponding deterioration of the quality of the dairy products made. Conditions radically changed when the state set up big enterprises and farms in this branch of the country's economy as well. The introduction of milking machines on a large scale played a decisive part in improving the quality of the milk. The pooling of the milk-producing enterprises into bigger units went hand in hand with the process of uniting the existing dairy farms in the setting up of big milk-processing enterprises whose number reached 60 in 1961. The great investment of capital in the building of big dairy farms and in supplying them with modern machinery and equipment called for the nationalization of all enterprises concerned with the distribution and processing of milk. Special services were set up at each administrative unit of the country for the administration and control of these enterprises.

The establishment of big modern enterprises to deal with the distribution and processing of milk made it possible to increase the variety of dairy products made in the country. The cow milk now obtained is processed into butter, yoghurt, curds, certain types of hard Dutch cheeses, white brined cheese, and the Cheddar cheese in recent years. The buffalo milk obtained is, as a rule, mixed with cow milk and used in making yoghurt since it greatly improves the quality and taste of this product. The sheep milk produced is used in making Kashkaval, white brined cheese, and Roquefort cheese. A number of caves in the country have been adjusted to this end, and some of them can hold several thousand tons of cheese today. The white brined cheese and the Kashkaval are products which are of interest to countries of warmer climate as well. The technological processes involved in the production of white brined cheese are simple and require no great amounts of complicated equipment. Both maturing and keeping the cheese is done in sour brine and this requires no particular conditions or temperatures.

Prior to the war, this cheese used to be made of sheep milk alone. Today, the microbiological and physicochemical studies undertaken in this field have led to the discovery of a new technology of preparing high-grade white brined cheese from cow milk as well. At the same time, in view of the high biological value of the proteins in the milk and of their utilization in the diet of the population, an new type of white brined cheese was created made of cow milk, which includes the soluble proteins in the milk. Thanks to long experience and to the scientific substantiation of the new technological processes devised, the white brined cheese

produced in Bulgaria ranks first among the 16 types of cheese made in the Balkans. Raw sheep milk of a comparatively high acid content is used in making Kashkaval. One of the interesting features in the technology involved in the preparation of this cheese, - heating the curdled mass to 70 or 75° C before the latter is formed into cheese cakes, aims at destroying the larger part of the existing microflora and at stopping the rapid processes of fermentation. This makes it possible for the Kashkaval to "ripen" under conditions of higher temperatures. The type of "Balkan Kashkaval" evolved in Bulgaria is made into thick cakes with a high water content and a low content of salt. It is the best cheese of its kind and is well known far beyond the boundaries of the country.

As regards churning butter, this process has been greatly mechanized. The principal task now facing solution in the dairy industry of Bulgaria is the complete mechanization of the process of obtaining yoghurt and the mechanization of certain processes in the preparation of white brined cheese. Certain processes in the preparation of Kashkaval can also be mechanized. Complete mechanization has been introduced only in making the Cheddar Cheese. There are almost unlimited possibilities of producing this type of cheese in Bulgaria.

The introduction of new machinery in the country's dairy industry and the perfectioning of the existing machines and equipment set high requirements before workers and specialists engaged in this particular branch of industry. That is why the training of efficient workers and specialists is one of the most important features of the programme of undertakings related to the development of the dairy industry. These specialists are now receiving training in three vocational high-schools, one technical college and two higher institutions of learning.

A Dairy Industry Research Institute was set up in 1960 to study the problems that arise in practice and to help in the application of the achievements of science all over the world. This institute has the task of supplying bacterial cultures to all enterprises in the country which need them. This centralization played a valuable part in improving the quality of dairy products obtained in Bulgaria at present.

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Agenda Item: C.5.3

Bulgaria

THE DAIRY INDUSTRY IN THE PEOPLE'S REPUBLIC OF BULGARIA

By Prof. Nikola DIMOV,
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THE DAIRY INDUSTRY IN THE PEOPLE'S REPUBLIC OF BULGARIA

Professor Nikola Dimov, Director of the
Dairy Industry Research Institute

One of the specific features of milk-production in Bulgaria which is bound to affect the very structure of the country's dairy industry is the production of cow, sheep and buffalo milk, with the ratios among the three types changing constantly as a result of the growing production of cow milk. Whereas before the war the quantity of sheep milk whose production has a seasonal character accounted for 87 per cent of the total amount of milk processed in the country, this percentage dropped to only 24 in 1961. The milk-processing enterprises of the period prior to the war were small, they had no modern equipment and operated on a seasonal basis. There were a total of 1,159 such small enterprises during this period, 662 of which were in private hands and 497 were co-operative. The average annual capacity of one of these enterprises was 63 tons. The principal dairy products obtained were the yellow cheese, known as kashkaval, and the white brined cheese made from sheep milk.

Immediately after the war all dairy farms were reorganized on a co-operative footing and the supply of milk to the population was taken over by the respective people's councils. A special enterprise called "Mlekokoop" at the Central Union of Co-Operatives became in charge of all milk-processing in the country. The rapid industrialization of the country led to the building of new industrial centres. The need to supply their population with fresh milk and dairy products called for the organization of modern enterprises whose number reached 60 in 1961. All milk-processing enterprises were nationalized during the same year. The establishment of big modern enterprises to deal with the distribution and processing of milk made it possible to increase the variety of dairy products made in the country. The cow milk obtained is processed into butter, yoghurt, curds, certain types of hard Dutch cheeses, and the Cheddar cheese in recent years. The buffalo milk obtained is mixed with cow milk and used in making yoghurt, while sheep milk is used in making Kashkaval, white brined cheese, and Roquefort cheese. In view of the high biological value of the proteins in the milk and of their utilization in the diet of the population, a new type of white brined cheese was created, made of cow milk, which includes the soluble proteins in the milk. The comparatively simple technological processes involved in the production of white brined cheese and Kashkaval make it possible for these two cheeses to be produced by conntries lacking sufficient modern equipment, as well as by countries of a comparatively warmer climate. The training of specialists for the needs of the country's expanding dairy industry is done in three vocational high-schools, one technical college, and two higher institutions of learning. A special Dairy Industry Research Institute was set up to carry out pertinent studies in this field.

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